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ELIZABETH G. BRITTON AND F. J. H. MERRILL.

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With the compliments of
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The Flora of the Amboy Clays.

By J. S. Newberry.

(Abstract.)

The Amboy clays of New Jersey represent the middle portion of the Cretaceous system, and are equivalents of the Lower Chalk of England. This has been known in a general way for many years, since the clays contain angiosperm leaves, and this botanical group, beginning in the earliest epoch of the Cretaceous age, shows its first considerable development in the Middle Cretaceous; and the green-sands which overlie the clays are full of the mollusks which are characteristic of the Upper Chalk.

The Amboy clays are several hundred feet in thickness, and contain a great number of leaf impressions, which are, to a large extent, different in the different beds. Perhaps a hundred distinct species have been collected from them up to the present time, and it is evident that they hold a very rich and interesting flora. As the clays are of great economic importance, and are likely to be worked at many places, perhaps for hundreds of years, this flora will probably become better known than that of any other geological formation except the Coal Measures. Unfortunately most of the leaf impressions hitherto obtained from the clay pits have proved perishable—a thick sheet of carbonaceous matter occupying the place of the original leaf, and in fresh specimens contrasting beautifully with the light colored clay, but cracking, when dried, to a powder that may be blown off with the breath. For this reason the collections formerly made have been lost, and the study of the flora has been delayed. Within a few years past, however, beds have been found at South Amboy and Woodbridge in which the leaves are represented by a thin film of brown carbonaceous matter, or a coffee colored stain, in which the nervation is distinctly discernible. From

these beds Dr. Britton, Mr. Hollick and Mr. I. H. Woolson have obtained many hundred specimens which are permanent and are satisfactory objects of study. These I have lately had under consideration, have had most of them carefully drawn, and of these drawings have composed about fifty quarto plates, some of which I now have the pleasure of exhibiting. This material gives the first satisfactory view of the flora which it represents, and enables me to make this contribution to a knowledge of the vegetation, that flourished in the region about the mouth of the Hudson, in the Cretaceous age.

It will, of course, be a long time before a full description of this flora can be given, but the hundred species of ferns and arborescent plants now before us may probably be regarded as a fair sample of it; and as a flora of similar botanical character has been exhumed from rocks of about the same geological age in the interior of this continent, in Greenland and in Germany, we may infer that this group of plants fairly represents the vegetation of the temperate zone in the Northern Hemisphere at the middle of the Cretaceous age.

As is known to most botanists and geologists, a great change in the plant life of the globe took place at the close of the palæozoic ages. Then the coal flora, consisting of acrogens with some gymnosperms —lycopods, equiseta, and ferns with conifers—gave place to what is known as the *mesozoic flora*, which consisted mainly of cycads, conifers and ferns; the cycads predominating and giving a special aspect to the vegetation. In the Triassic and the Jurassaic ages, and through the first epoch of the Cretaceous age, this flora apparently flourished over the whole world. Toward the middle of the Cretaceous age angiosperms began to appear and soon became the prevailing style of vegetation; this has continued, with many changes of degree but little of kind, to the present day.

The beginnings of the angiospermous flora have apparently been found in the Kome beds of Greenland and in the Potomac group of Virginia, of which the flora is now being studied by Prof. W. M. Fontaine. Here a few angiosperms are found mingled with an abundant flora of cycads, conifers and ferns, but as yet without any discovered transitional forms between these botanical groups.

In the Amboy clays and in the Dakota rocks of the West, which next succeed in time the Potomac clays, the angiosperms are predominant and exhibit a variety and a botanical rank which are surprising. The Dakota flora which has been illustrated in the important memoirs of Mr. Lesquereux and the less voluminous contributions of Prof. Heer and myself, now stands represented by about 200 nominal species, of which 30 are cryptogams and gymnosperms; the remainder are angiosperms. Excluding fragmentary and doubtful material, we have about 140 species which, whatever their botanical relations may be, are certainly distinct from each other; and of these more than three-fourths are arborescent angiosperms.

The flora of the Amboy clays is closely related to that of the Dakota group—most of the genera and some of the species being identical—so that we may conclude they were nearly contemporaneous, though the absence in New Jersey of the Fort Benton and Niobrara groups of the upper Missouri and the apparent synchronism of the New Jersey marls and the Pierre group indicate that the Dakota is a little the older.

At least one-third of the species of the Amboy clays seem to be identical with leaves found in the upper Cretaceous clays of Greenland and Aachen (Aix la Chapelle), which not only indicates a chronological parallelism, but shows a remarkable and unexpected similarity in the vegetation of these widely separated countries in the middle and last half of the Cretaceous age. The botanical character of the flora of the Amboy clays will be seen from the following brief synopsis:

Algæ. A small and delicate form allied to *Chondrites.*

Equiseta and *Fungi.* None yet discovered.

Ferns. Twelve species generally similar and in part identical with those described by Heer from the Cretaceous beds of Greenland and referred to the genera *Dicksonia*, *Gleichenia* and *Aspidium.*

Lycopods. None yet discovered.

Cycads. Two species probably identical with the forms from Greenland described by Heer under the names of *Podozamites marginatus* and *P. tenuinervis.*

Conifers. Fourteen species belonging to the genera *Moriconia*, *Brachyphyllum*, *Cunninghamites*, *Pinus*, *Sequoia*, and

others referred by Heer to *Juniperus*, *Libocedrus*, *Frenelopsis*, *Thuya* and *Dammara*. Of these the most abundant and most interesting are *Moriconia cyclotoxon*—the most beautiful of conifers—and *Cunninghamites elegans*, both of which occur in the Cretaceous clays of Aachen, Prussia, and Patoot, Greenland. The *Brachyphyllum* was a large and strong species with imbricated cones eight inches in length.

The angiosperms form about seventy species, which include three of *Magnolia*, four of *Liriodendron*, three or four of *Salix*, three of *Celastrophyllum* (of which one is identical with a Greenland species), one *Celastrus* (also found in Greenland), four or five *Aralias*, two *Sassafras*, one *Cinnamomum*, one *Hedera*, with leaves that are apparently identical with those described by Heer as belonging to *Andromeda*, *Cissites*, *Cornus*, *Dewalquea*, *Diospyros*, *Eucalyptus*, *Ficus*, *Ilex*, *Juglans*, *Laurus*, *Menispermites*, *Myrica*, *Myrsine*, *Prunus*, *Rhamnus*, and others not yet determined.

Some of the Aralias had palmately lobed leaves nearly a foot in diameter—and two of the tulip trees *(Liriodendron)* had leaves quite as large as those of the living species. One of these had deeply lobed leaves like those of the white oak. Of the other the leaves resembled those of the recent tulip tree, but were larger. Both had the peculiar emargination and the nervation of *Liriodendron*.

Among the most interesting plants of the collection are fine species of *Bauhinia* and *Hymenæa*. Of these the first is represented by a large number of leaves, some of which are six or seven inches in diameter. They are deeply bilobed and have the peculiar and characteristic form and nervation of the leaves of this genus. *Bauhinia* is a leguminous genus allied to *Cercis*, and now inhabits tropical and warm temperate climates in both hemispheres. Only one species occurs in the United States, *Bauhinia lunarioides*, Gray, found by Dr. Bigelow on the Rio Grande.

Hymenæa is another of the leguminosæ and inhabits tropical America. A species of this genus has been found in the Upper Cretaceous of France, but quite different from the one before us, in which the leaves are much larger, and the leaflets are united in a common petiole, which is winged; this is a modification not found in the living species, and one which brings it nearer to *Bauhinia*.

But the most surprising discovery yet made is that of a number of quite large helianthoid flowers which I have called *Palæanthus*. These are three to four inches in diameter, and exhibit a scaly involucre enclosing what much resembles a fleshy receptacle with achenia. From the border of this radiate a number of ray florets, one to two inches in length, which are persistent and must have been scarious like those of *Heliochrysum*. Though these flowers so much resemble those of the *Compositæ*, we are not yet warranted in asserting that such is certainly their character. In the Jurassic rocks of Europe and India some flowers not very unlike these have been found, which have been named *Williamsonia* and referred to cycads by Carruthers. A similar fossil has been found in the Cretaceous rocks of Greenland and named by Heer, *Williamsonia cretacea*, but he questions the reference of the genus to the *Cycadeæ* and agrees with Nathorst in considering all the species of *Williamsonia* as parasitic flowers allied to *Brugmansia* or *Rafflesia*. The Marquis of Saporta regards them as monocotyledons similar to *Pandanus*. More specimens of the flowers now exibited will perhaps prove, what we can now only regard as probable, that the *Compositæ* like the *Leguminosæ*, *Magnoliaceæ*, *Celastraceæ*, and other highly organized plants formed part of the Cretaceous flora. No composite flowers have before been found in the fossil state, and as these are among the most complex and specialized forms of florescence, it has been supposed that they belonged only to the recent epoch, where they were the result of a long series of formative changes.

The presence of *Hymenæa*, *Bauhinia* and *Cinnamomum* might be considered as proof that the climate in which these plants grew was tropical, but the willows, magnolias, aralias and other elements in the flora are rather indicative of a warm temperate climate.

No palms have yet been found in the lower or middle Cretaceous, though they are abundant in the upper Cretaceous and Tertiary beds in localities far north of New York. We may therefore infer that when the Amboy clays were deposited palms had not yet appeared in the vegetation of the globe.

A large number of fruits have been found in the Amboy clays, but with the exception of those which belong to the conifers and cycads their botanical relations are not yet clearly made out.

On the Nomenclature of the Leaves of Fossil Dicotyledons.*

In Vol. xxv., Nos. 1 and 2, of the "Botanisches Centralblatt," A. G. Nathorst publishes an interesting article in which he discusses the difficulties which present themselves to the palæontologist in classifying and naming fossil dicotyledons on the characters of their leaves only.

The author proposes the following methods which he intends to employ in his future publications, and invites his co-workers in this field to adopt the same rule, viz. :

Those species of which leaves only are known, are to be named after the genus with which they agree best, with the addition of the termination—*phyllum*. Therefore, we ought not to say *Magnolia Capellini*, *Heer.*, but *Magnoliphyllum Capellini*, etc. Such a name would indicate that the leaf in question seems to resemble most the leaves of a *Magnolia*, and therefore possibly belongs to that genus. If afterwards, together with this leaf, flower and fruit should be found, which, without any doubt, belong to Magnolia, the leaf could then be classified with Magnolia. In the case of leaves for which analagous forms are not to be found among living plants, independent generic names are to be used, as heretofore, e. g., *Credneria*, *Protophyllum*, etc.

Another part of the article refers to the identification of fossil leaves found in different localities, at great distances from each other. In most such cases slight differences in form, etc., are, at present, not taken into consideration, and the leaves are placed in the same species. Thus the leaf A is identified with the leaf B (from a distant locality), afterward C with B, then D with C, and finally D with A; in reality, the name of this supposed single species may possibly stand for a whole group of species.

In order to meet this difficulty the author proposes to employ a ternary nomenclature. Suppose a leaf were found in Japan which resembles *Acer trilobatum* so much that it would not be advisable to make a new species of it, although the similarity is not perfect; this leaf ought to be called *Acer trilobatum Japonicum*.

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* Abstracted by Professor Jos. Schrenk.